

Multivariate Descriptive Statistics

Analysis of the dataset

The dataset to analyze is composed of the red and white variants of the Portuguese “Vinho verde” wine. In total, there are 6495 different instances of wines, where 4898 are white wine and 1597 red wine. On the other hand, the dataset has 12 variables based on physicochemical tests on different wines plus two categorical variables, one for grading the wine quality by experts between 0 (very bad) and 10 (very excellent) and another binary variable, 0 = white wine and 1 = red wine.

The following Table 1 summarizes the distribution of the quantitative variables, highlighting their minimum, maximum, mean and standard deviation values.

	min	max	mean	SD
fixed_acidity	3,800	15,900	7,215	1.296588
volatile_acidity	0,0800	1,5800	0,3396	0.164583
citric_acid	0,0	1,6600	0,3187	0.1452326
residual_sugar	0,600	65,800	5,444	4.758494
chlorides	0,00900	0,61100	0,05602	0.03503299
free_sulfur_dioxide	1,00	289,00	30,52	17.74849
total_sulfur_dioxide	6,0	440,0	115,8	56.52657
density	0,9871	1,0390	0,9947	0.002999095
pH	2,720	4,010	3,219	0.1608116
sulphates	0,2200	2,00	0,5313	0.148822
alcohol	8,00	14,90	10,49	1.192768

Table 1: Summary distribution of the quantitatives variables.

Distribution of target variables

Type

As we have already seen, the distribution of the **type** of wines is considerably unbalanced, since the 75% of the observations are white wines, and the other 25% are red wines.

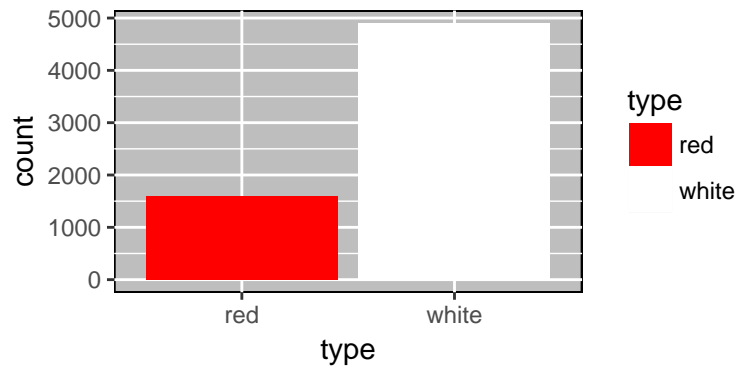


Figure 1: Distribution of wines according to ‘type’

Quality

The `quality` is actually a categorical variable, as we can see in the following histogram. However, we will treat it as a continuous variable within the regression modeling.

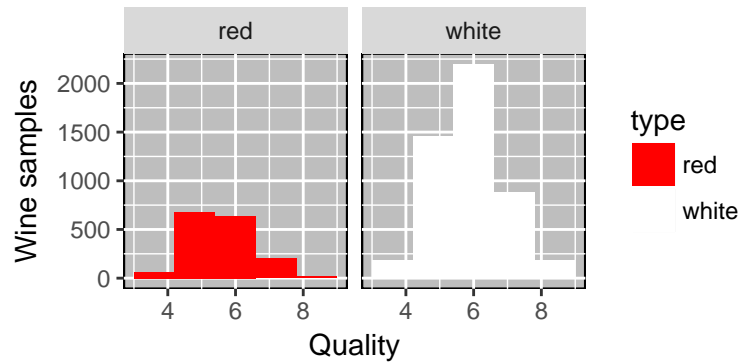


Figure 2: Histogram of wines quality: red vs. white

Correlation analysis

Let's now study the linear relationships between wine quantitative variables. The variables to be inspected are the quantitative attributes `fixed_acidity`, `volatile_acidity`, `citic_acid`, `residual_sugar`, `chlorides`, `free_sulfur_dioxide`, `total_sulfur_dioxide`, `density`, `pH`, `sulphates` and `alcohol`.

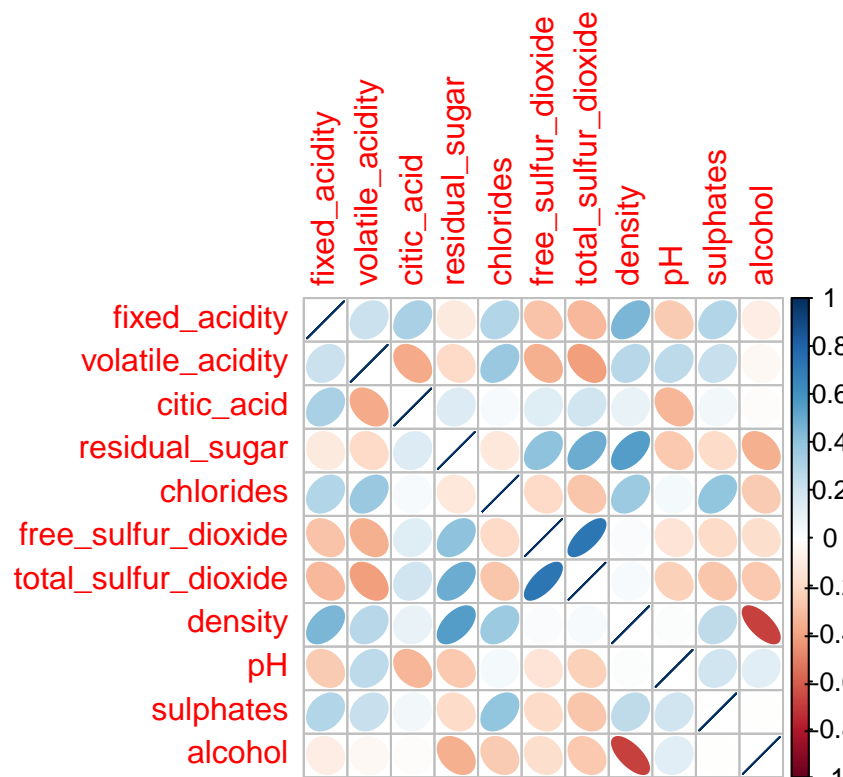


Figure 3: Matrix of pairwise correlations

As we can see, the linear relations between variables are weak (the tonality of the colors is, in general, soft).

We can only assure that **free_sulfur_dioxide** obviously is positive related with the **total_sulfur_dioxide**. Also the **alcohol** has negative effects on the **density** of the wines. To conclude, it is interesting to mention that the **sulphates** does not seem linearly related with any of the other variables.

Coefficients of determination

The coefficients of determination can also give us a good insight into linear relationships within the data. As the Table 2 below displays, important linear relations are present in this set. Specifically, **density** and **residual_sugar** are the most linearly explained by the other variables. Slightly less influenced, but still scoring high, are **fixed_acidity** and **alcohol**.

	fixed_acidity	volatile_acidity	citric_acid	residual_sugar	chlorides	free_sulfur_dioxide	total_sulfur_dioxide	density	pH	sulphates	alcohol
R-squared	0.7957831	0.4866891	0.3776351	0.8616690	0.3870994	0.5324288	0.6598145	0.9371628	0.6058479	0.3513432	0.7908480

Table 2: Coefficient of determination for each of the analyzed variables.

As the Table below displays, important linear relations are present in this set. Specifically, **density** and **residual_sugar** are

Effective dependence coefficient of the R matrix

Until this point, our analysis shows weak linear relations in this dataset. Further proof of this fact can be found in the effective dependence coefficient of the R matrix: $D(R) = 0.4052199$. This means that, altogether, linear dependences explain only 40% of the variability of the data. Hence, the linear regression model will probably not perform well in this dataset.